DOCUMENT RESUME

ED 349 167 SE 052 965

AUTHOR Berlin, Donna F.; White, Arthur L.
TITLE A Network for Integrated Science and Mathematics Teaching and Learning. NCSTL Monograph Series, #2.
INSTITUTION National Center for Science Teaching and Learning, Columbus, OH.
SPONS AGENCY National Science Foundation, Washington, D.C.; Office of Educational Research and Improvement (ED), Washington, DC.
PUB DATE Sep 91
CONTRACT NSF-TPE-9050047; R117900062
NOTE 7p.
PUB TYPE Viewpoints (Opinion/Position Papers, Essays, etc.) (120)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Curriculum Development; Elementary Secondary Education; *Integrated Curriculum; *Interdisciplinary Approach; Mathematics Education; *Mathematics Instruction; Science Education; *Science Instruction; *Teaching Methods
IDENTIFIERS National Center for Science Teaching and Learning; *Wingspread Conferences

ABSTRACT

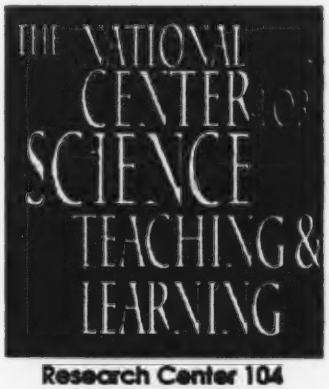
This monograph presents a summary of the results of the Wingspread Conference in April, 1991 concerning the viability and future of the concept of integration of mathematics and science teaching and learning. The conference focused on three critical issues: (1) development of definitions of integration and a rationale for integrated teaching and learning of science and mathematics; (2) specification of guidelines for infusion of integrated teaching and learning of science and mathematics into school practice; and (3) identification of high priority research questions related to integrated teaching and learning of science and mathematics. The report indicates that working groups and other participants were unable to come to a consensus regarding the definition of "integration," but that a rationale for its infusion into school practice was developed at the conference. A document review reported at the conference indicated that 22 out of 423 citations in the field of integration concerned research. It is concluded that this paucity of research in the field sets a challenge for science education reformers. (MDH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

A Network for Integrated Science and Mathematics Teaching and Learning

Donna F. Berlin
Arthur L. White

NCSTL Monograph Series, #2
September 1991



Research Center 104
1314 Kinnear Road
Columbus, OH 43212
(614) 292-3339

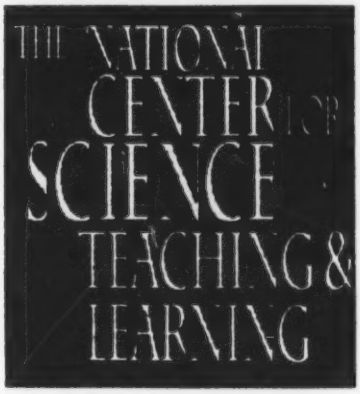
U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

BEST COPY AVAILABLE



A Network for Integrated Science and Mathematics Teaching and Learning

Donna F. Berlin and Arthur L. White

The NCSTL Monograph Series
Number 2

In this summary of the results of a conference concerning the viability and future of the concept of integration of mathematics and science teaching and learning, the authors assert that the paucity of research in the field of integration sets a challenge for science education reformers

---

President Bush has set as one of America's educational goals for the year 2000: "U.S. students will be first in the world in science and mathematics achievement." Integration is repeatedly referred to in mathematics and science education reform as a necessary component for science and mathematics education (see for example the American Association for the Advancement of Science [AAAS] Project 2061; the National Science Teachers Association [NSTA] Scope, Sequence, and Coordination; and the National Council of Teachers of Mathematics [NCTM] Curriculum and Evaluation Standards). Consider the following examples from recent documents on science and mathematics education reform: They are indicative of the current emphasis on the concept of integration.

Writing of this paper supported by the National Center for Science Teaching and Learning under grant #R117Q00062 from the Office of Educational Research and Improvement, U.S. Department of Education, as well as National Science Foundation grant #TPE-9050047

The alliance between science and mathematics has a long history, dating back centuries. Science provides mathematics with interesting problems to investigate, and mathematics provides science with powerful tools to use in analyzing data. ... Science and mathematics are both trying to discover general patterns and relationships, and in this sense they are part of the same endeavor.
– Rutherford & Ahlgren, *Science for All Americans*, 1990

Since mathematics is both the language of science and a science of patterns, the special links between mathematics and science are far more than just those between theory and applications. The methodology of mathematical inquiry shares with the scientific method a focus on exploration, investigation, conjecture, evidence, and reasoning. Firmer school ties be-

tween science and mathematics should especially help students' grasp of both fields.
– National Research Council, *Reshaping School Mathematics. A Philosophy and Framework for Curriculum*, 1990

The Wingspread Conference

In an effort to explore ways to improve science and mathematics education in elementary, middle, and high schools through integrated teaching and learning of these two disciplines, the School Science and Mathematics Association (SSMA), the National Science Foundation, and the Johnson Foundation sponsored a conference including educators, professional association leaders, curriculum developers, and members of the scientific community including scientists, mathematicians, and technologists. The conference took place at the Johnson Foundation Wingspread Conference Center in April of 1991.

The purpose of the Wingspread conference was to gain a better understanding of integrated science and mathematics teaching and learning by focusing on three critical elements: 1) development of definition(s) of integration and a rationale for integrated teaching and learning of science and mathematics; 2) specification of guidelines for infusion of integrated teaching and learning of science and mathematics into school practice; and 3) identification of high priority research questions related to integrated teaching and learning of science and mathematics.

At the opening session, Dr. Donna Berlin of The Ohio State University at Newark presented a review of the literature on integration of science and mathematics education. Her overview of the theoretical, research, curriculum, and instructional literature in the field of integration revealed that of 423 citations, approximately 77% were essentially science instructional activities which included mathematics-related concepts. These mathematics concepts were rarely stated as objectives in the activities. This type of integration is a product of the nature of the activity rather than of conscious design, and involves isolated activities rather than organized programs.

Berlin's review highlighted a profound lack of research documents. Out of 423 citations, only 99 – 23% – related to theory and research. Of these 99 citations, 77 concerned theory and 22 concerned research. Furthermore, some of these 22 were only tangentially related to the integration of science and mathematics. To compound the problem, inconsistent definitions of integration precluded valid comparisons within the research literature. Research was often incomplete: researchers examined the effect of integration on science or mathematics outcomes, but not both. There is clearly a need for careful conceptualization and additional research on integrated science and mathematics teaching and learning.

A document review discovered only 22 research papers on integration

The Question of Definition

The definitions of "integration" suggested by the conference participants varied. Although a consensus was not reached, several key components did emerge. Conference participants discussed the need to attend to integrated content (what is taught) and integrative teaching methods (how it is taught), and concluded that these needs may be quite distinct.

One working group proposed the following definition: "Integration infuses mathematical methods in science and scientific methods into mathematics such that (it) becomes indistinguishable as to whether it is mathematics or science." Another group suggested that integration is the process of blending the quantifying aspects of mathematics and the contextual aspects of science. Some participants cautioned against the merging of the two disciplines for fear of losing the important philosophical, methodological, and historical differences between the two.

It is not clear to what extent mathematics and science should be integrated. The key question is clearly this: Which concepts and/or processes of mathematics and science are naturally related and which should remain discipline specific?

Other points of notable agreement surfaced during the discussions. Many of the participants championed a "project approach" to connect science, mathematics, and events outside the classroom. Proponents of the project approach cited efficient use of time and ability to make knowledge relevant (less inert) as its major advantages. As described by John Bransford of the Learning Technology Center at Vanderbilt University, projects are "... helping students understand the value of the knowledge that they are learning and its connections with other aspects of their knowledge." Conference participants clearly valued a constructivist perspective. According to Lynn Steen of St. Olaf College, "Children learn by doing, their actions help construct their personal knowledge. Involvement in learning increases as does long-term retention."

The Challenge of Infusion

Conference participants were generally in accord on the integrated teaching of science and mathematics; there was, however, less agreement on the integration of content and processes. Although "integration" eluded definition, conferees arrived at a rationale for its infusion into school practice. The potential benefits cited included:

- √ helping students realize that mathematics and science are everywhere
- √ providing opportunities for out of school resource persons to become involved
- √ stimulating group interaction and social development
- √ bridging understanding between concrete and abstract representations
- √ developing quantitative and causal appreciation of reality with emphasis on information use rather than acquisition
- √ providing opportunities to put ideas together and deepen understanding
- √ encouraging relevant, exciting science and mathematics in schools.

John Bransford summed up his view of integration as follows:

> [It is] highly desirable not as an end in itself, but as a means to achieve other goals. The goals that we want to achieve are to help students experience the excitement and importance of mathematical and scientific inquiry, to realize that it is within their potential to engage in such inquiry, and to offer them the kinds of experiences that will set the stage for lifelong learning.

The debate concerning the infusion of integrated science and mathematics into classroom practice raised a number of issues including resources and methodologies, integrative curricula, teacher preparation, outcome assessment, and implementation strategies.

The conferees agreed that teacher preparation is a major hurdle to integrating science and mathematics into school practice. Teacher-related obstacles include teacher knowledge, experience, attitudes, and beliefs. In order to optimize meaningful linkage between science and mathematics, it must be determined what teachers need to know about a number of issues, including

"Technology can blast through the barrier between science and mathematics..."

- √ the nature of science and mathematics
- √ concepts and principles of science and mathematics
- √ interrelationships of processes and skills of science and mathematics
- √ curriculum, instruction, and learning the-

ories

√ selection and sequencing of learning activities

√ organization and management of the learning environment

√ comprehensive assessment practices.

There are other issues and influences which can be described as external to the classroom including school structure, organization, and administration; social and cultural influences; public perceptions and incentives; and economic and political forces. The traditional boundaries between content areas, scheduling practices, criteria for resource allocation, assessment practices (format and focus), collaboration incentives, and public perceptions need to be described and understood.

Several participants proposed technologically-based solutions to the infusion issue. Carl Berger of the University of Michigan suggested that "technology can blast through the barrier between science and mathematics... This technology will cause us to rethink our pedagogy." John Bransford recommended the use of videodisc-based anchors to create environments that can be explored and discussed in a collaborative manner. The use of these and other types of electronic communications may provide avenues for cross-discipline, inquiry-based learning.

The Next Step

John Dossey of Illinois State University summed up the difficulties of translating ideas into action:

> Integrated mathematics and science programs for school curricula have a strong support at the discussion level. However, ... significant challenges must be addressed. The degree to which a carefully constructed program for the development of sample integrated programs, research agenda to document their efficiency, production of materials to support teachers, programs of professional development for teachers, and plans for developing public support are developed, implemented, and monitored will, in the end, determine the probability of the existence of integrated programs of mathematics and science education in American schools.

Follow-up activities to this conference will be facilitated by a network of interested and concerned professionals. The network includes electronic mail communications such as SMILENET (the Science and Mathematics Integrated Learning Environment Network); newsletter articles with broad dissemination such as those published by the National Association for Research in Science Teaching (NARST), NCTM, NSTA, and SSMA); special publications such as research reports, monographs, collections of learning activities, bibliographies, and resource lists; workshop, symposia, and paper presentations (e.g., AAAS, ASCD [Association for Supervision and Curriculum Development], NARST, NCTM, NSTA, SSMA); and a collaborative task force on the integration of science and mathematics education involving SSMA and NARST.

The National Center for Science Teaching and Learning (NCSTL) conducts, coordinates, and facilitates research on the integration of science with other content areas. Donna Berlin, Coordinator of the NCSTL's research on integration, and Arthur White, the Center Director, are committed to sustaining research, development, communication, and dissemination efforts related to the integrated teaching and learning of science and mathematics.

Additional information regarding the Wingspread Conference on Integration, including a list of participants, may be obtained upon request to Drs. Donna F. Berlin and Arthur L. White at:

NCSTL
Research Center 104
1314 Kinnear Road
Columbus, OH 43212

REFERENCES

American Association for the Advancement of Science. (1989). *Project 2061. Science for all Americans. Summary*. Washington, DC: Author.

Bush, G. (1990). *America 2000. An education strategy*. Washington, DC: U.S. Department of Education.

National Council of Teachers of Mathematics. Commission of Standards for School Mathematics. (1989, March). *Curriculum and evaluation standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

National Research Council. (1989). *Everybody counts. A report to the nation on the future of mathematics education*. Washington, DC: National Academy Press.

National Research Council. (1990). *Reshaping school mathematics. A philosophy and framework for curriculum*. Washington, DC: National Academy Press.

Rutherford, F. J. and Ahlgren, A. (1990). *Science for all Americans*. New York, NY: Oxford Press.